In deposits that are relatively calcareous, such as sand and clay formations that contain much calcareous cementing material or deposits of marl, limestone, and chalk, the capacity of the percolating waters to take calcium and magnesium carbonates into solution by virtue of their content of carbon dioxide is exhausted at shallow depths. Waters from such formations do not generally increase in mineral content with increasing depth in the formation. Wells 20 to 40 feet deep in these formations yield water containing as much dissolved mineral matter as those several hundred feet deep.

In formations that contain little calcareous material, however, the waters must travel farther to exhaust their capacity to take calcium carbonate into solution. Waters from shallow depths in such formations are usually low in dissolved mineral matter. As the waters percolate downward they continue to take calcium and magnesium carbonate into solution until their carbon dioxide content is exhausted. With greater depth the mineral content then tends to remain relatively constant.

Some formations that are apparently devoid of calcareous material yield waters of low mineral content, even from great depths. Some of these deep waters carry considerable carbon dioxide and are corrosive.

The solution of calcium and magnesium carbonates constitutes the primary action between the percolating meteoric waters and the rock materials. However, many waters of the area are sodium bicarbonate waters, and some contain approximately equal quantities of calcium and sodium.

The same formation may yield waters of all these different types. In such a formation the calcium bicarbonate waters are usually the shallower waters, and the sodium bicarbonate waters are the deeper waters. The waters undergo an alteration in character with depth. The calcium and magnesium content decreases, the waters become softer, and at the same time the sodium content increases, the bicarbonate and total mineral content often remaining about the same. This phenomenon is shown in Fig. 1 by diagrams F, G, H, and I, which represent analyses of waters from different depths in the Black Creek formation in South Carolina. These waters appear to be the result of a secondary action between the waters and the rock materials —exchange of calcium and magnesium in solution in the waters for sodium of base-exchange minerals in the rock materials. Descriptions of the lithologic character of the formations of this area in geologic reports frequently note the fact that a certain formation is "glauconitic." Glauconite, or greensand, is a green granular silicate of potassium and iron that has pronounced base-exchange properties. It is formed near the mud line off continental shores and is consequently often found in sedimentary deposits like those that underlie this area. Certain hydrous alumino-silicates that are capable of base

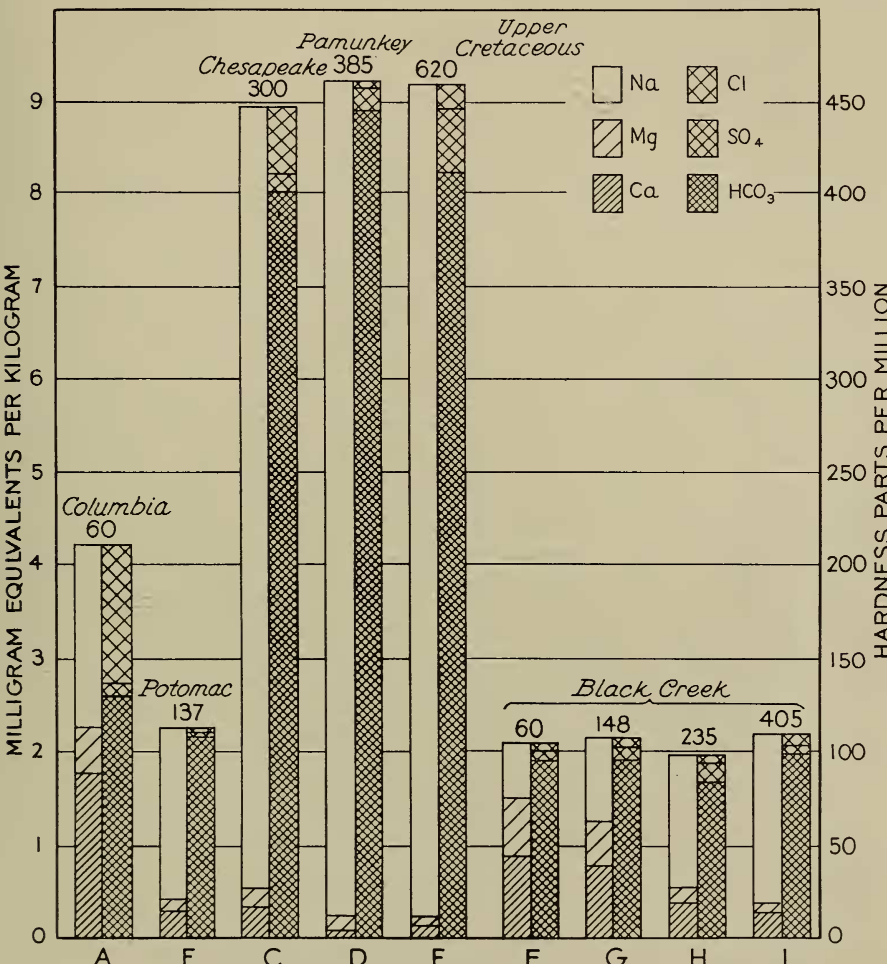


Fig. 1.—Composition of typical well waters in the Coastal Plain of Virginia and South Carolina. (Names above columns refer to stratigraphic units; numbers refer to depth of wells in feet.)

exchange, derived from the weathering of crystalline rocks, may also make up part of the clastic material of these sediments.

The depth at which softening begins varies with the relative proportion of calcium and magnesium carbonates to base-exchange minerals in the materials through which the water passes. If the base-exchange minerals are present in an amount at least proportional to the carbonates, the two processes are probably almost simultaneous, the calcium being exchanged almost as soon as it is taken into solution. If, however, the carbonates are present in the rock materials in amounts more than equivalent to the exchange minerals, or if the exchange capacity of the base-exchange minerals has been exhausted in the shallower materials, the ground waters must travel farther before being softened.

This phenomenon of natural water softening is particularly pronounced in the formations that underlie Virginia and North and South Carolina. In Virginia most of the waters from a depth of more than 100 or 150 feet are sodium bicarbonate waters, and many waters from even shallower depths contain some sodium bicarbonate, indicating that softening has begun to take place. The chemical composition of typical well waters in the Coastal Plain of Virginia from different depths in different formations is shown graphically on Fig. 1, A, B, C, D, and E. Many of the Virginia waters are characterized by a very high content of sodium bicarbonate, with as much as 250 to 350 parts per million of sodium and 500 to 700 parts of bicarbonate; the calcium and magnesium content of these waters is very low, and in many the sulfate and chloride are low (diagrams C, D, and E). The high content of bicarbonate in these waters and the comparatively shallow depths at which softening takes place indicate that (1) the percolating waters had, at the outset, a high content of carbon dioxide and, consequently, a high capacity for solution of calcium and magnesium carbonate, (2) the rock materials through which they passed were relatively calcareous, and (3) the proportion of base-exchange minerals to calcium and magnesium carbonates in the materials was relatively high.

There is little detailed information on the ground waters of North Carolina. The few analyses at hand indicate that softening is fairly complete at depths of about 100 or 150 feet.

The three most important water-bearing formations in South Carolina are the Tuscaloosa, the Black Creek, and the Peedee. Typical waters from different depths in the Black Creek formation are shown graphically in Fig. 1, diagrams F, G, H, and I. The waters from this formation are usually fairly low in dissolved mineral matter, generally containing less than 200 parts per million. The waters from the Tuscaloosa formation are similar in character to those from the Black Creek formation, although they generally contain less than 150 parts per million of dissolved mineral matter. The waters from the Peedee formation are more highly mineralized, usually having a mineral content of 500 to 750 parts per million. The deeper waters from the